Laser Propagation in the Maritime Environment

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Abstract

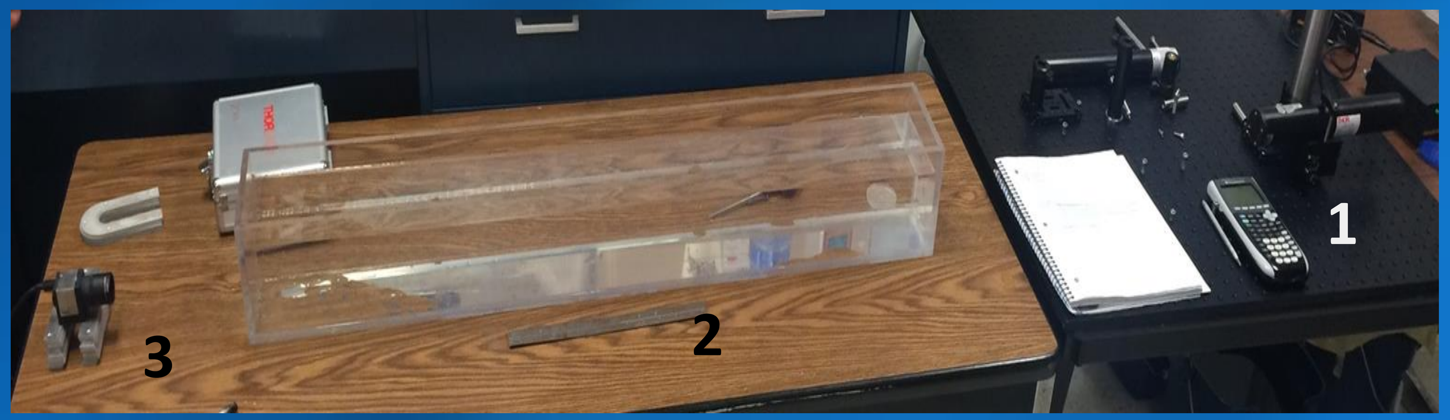
Lasers are a viable means of transferring information and have potential weapon capabilities. However, the propagation of the laser beam is subject to the medium through which it travels. This has prompted a study of beam propagation through various simulated maritime environments.

Background

A laser produces an intense beam of monochromatic light through photon emission.[1] As a laser beam propagates, the beam's radius steadily increases due to divergence of individual photons from the beam's center. This effect is magnified when photons encounter particles or propagate through permeable mediums of increasing density. Therefore, a beam will have an increased spot radius after propagating through water comparatively to air. Furthermore, differing conditions within the water itself, such as temperature and salinity, will serve to alter the beam's trademark characteristics.

Methods

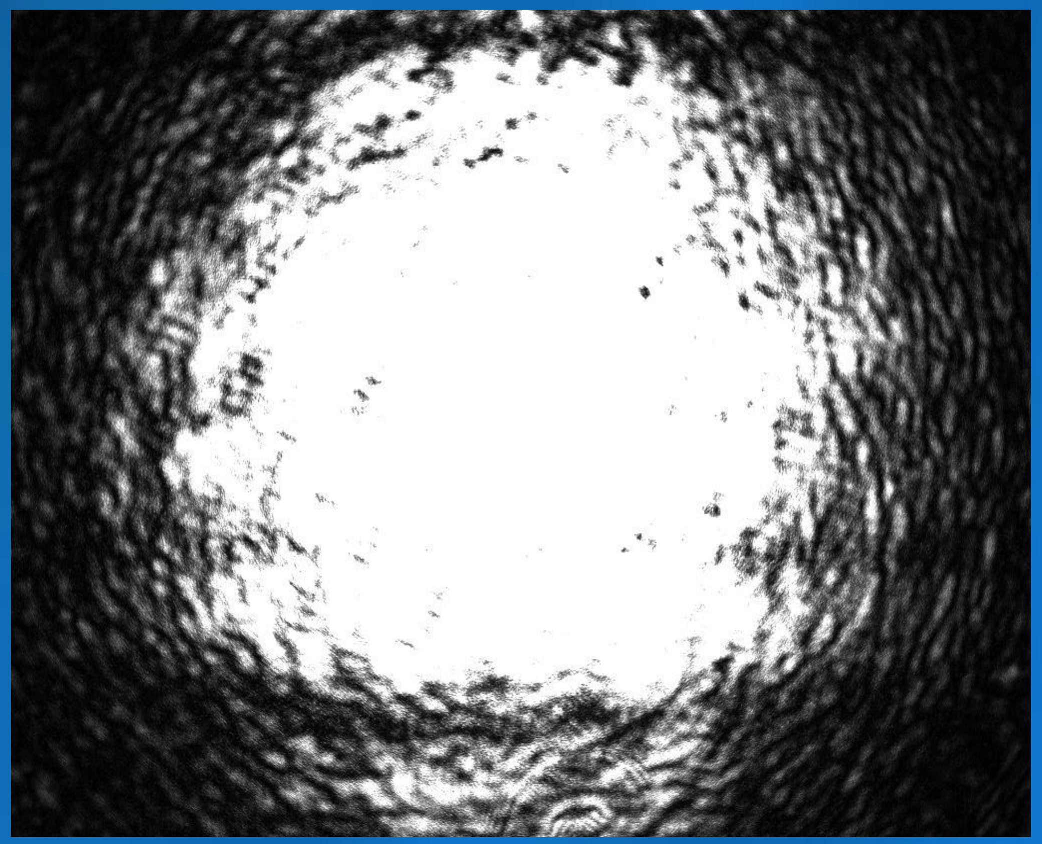
The beam's propagation was studied with a three part experimental system (see Figure 1) consisting of a laser, a water tank, and a camera. The Thorlab manufactured laser (1) emitted a 2 mW beam at a wavelength 633 nm. The water tank (2) measured 105x13x9 cm^3 and allowed for varying salinity and temperature to simulate the waters of Norfolk, VA (13.9℃ and 33 ppt) and Puerto Rico (26.7℃ and 37 ppt).[2,3] The Thorlab DCC1249C camera (3) captured images of the beam (specifically the photons) as they struck the camera.



(Figure 1: Experimental set up)

Results

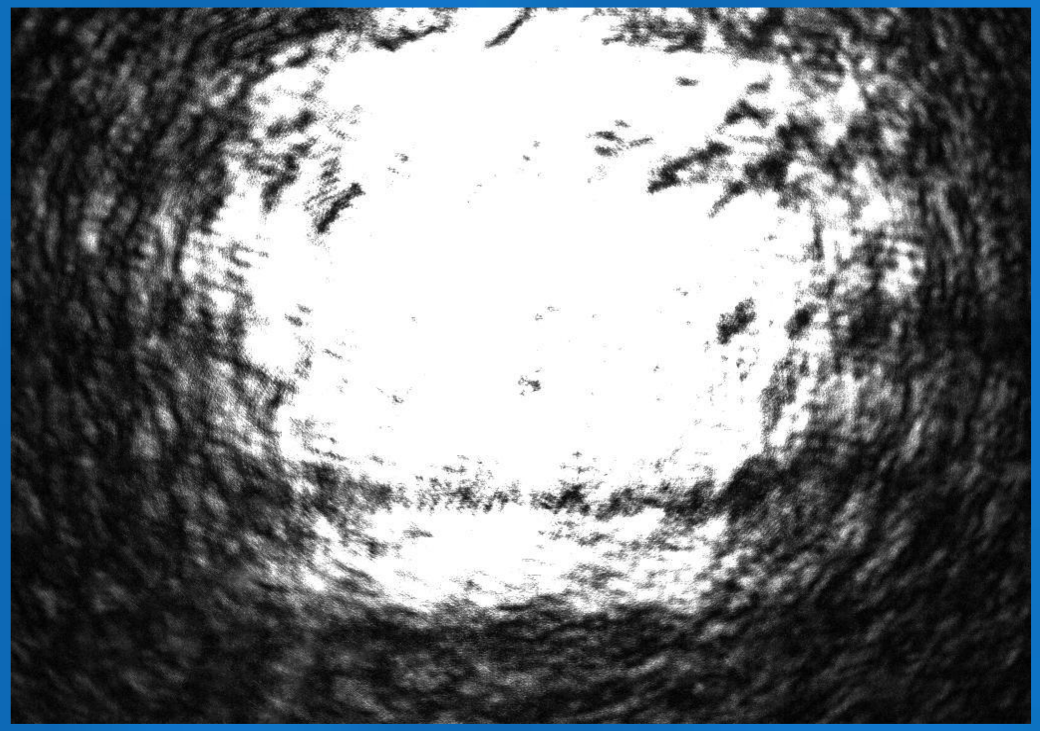
Control Simulation



(Figure 2: Beam propagation through distilled water)

(Figure 3: Beam in distilled water)

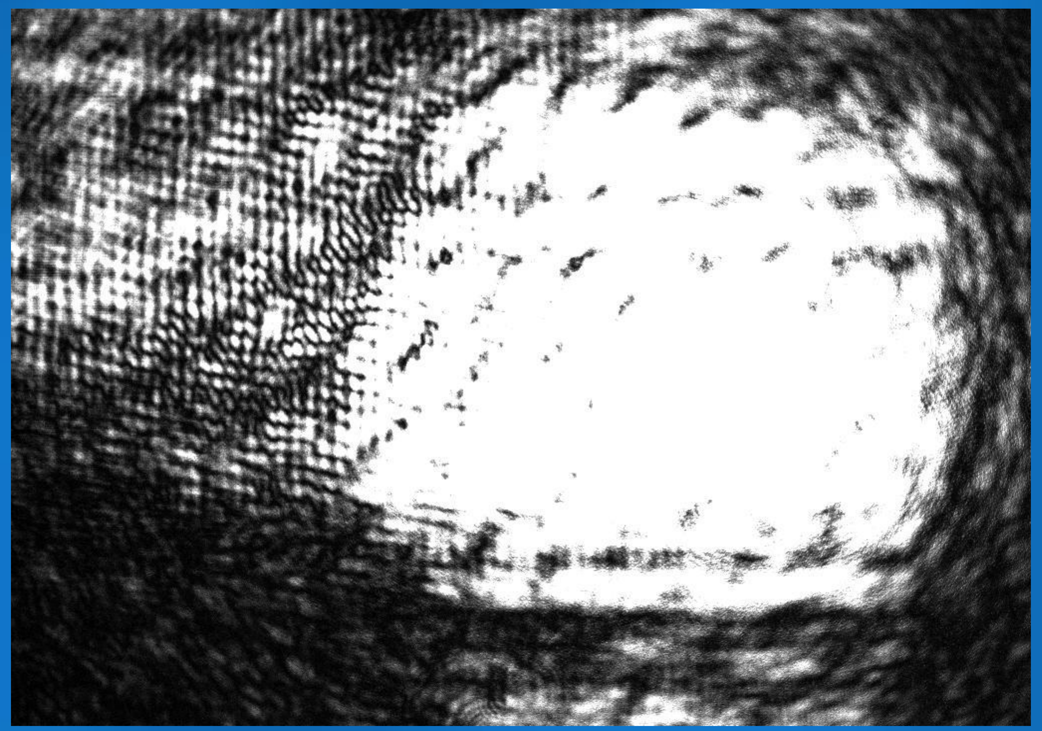
Norfolk Simulation



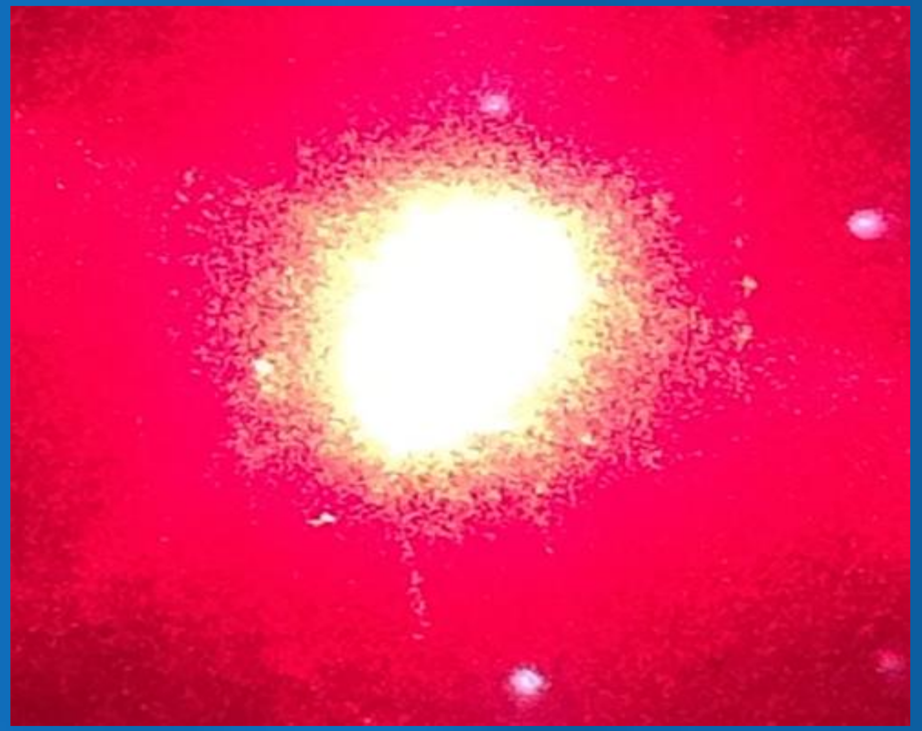
(Figure 4: Beam propagation through 13.9℃ and 33 ppt medium)

(Figure 5: Beam in 13.9℃ and 33 ppt medium)

Puerto Rico Simulation



(Figure 6: Beam propagation through 26.7℃ and 37 ppt medium)



(Figure 7: Beam in 26.7℃ and 37 ppt medium)

Results Continued

Images of the beams through the three media display the impact upon propagation at a range slightly greater than one meter. The images from the Norfolk simulation exhibit a greater degree of spreading than the baseline but still have a well defined and contained spot radius. The images from the Puerto Rico simulation exhibit an even higher degree of spreading and a much wider spot radius. These variations can be explained by both the temperature and salinity of the experimental groups. The Puerto Rico simulation had more particles in solution and a higher temperature, which led to increased photon diffraction from the beam's center.

Conclusion and Future Work

The research successfully imaged and demonstrated the effect various media had upon beam propagation. It was found that both environments had an adverse effect upon the beam's intensity while the Puerto Rico simulation had a greater negative impact. Future work should first simulate a wider variety of maritime environments and ultimately seek to provide a method for minimizing the spot radius, thus maximizing the beam intensity.

References

1. Wilson, J.; Hawkes, J.F.B.; *Lasers: Principles and Applications*, 1987, 1-18.
2. "Coastal Water Temperature Guide." *Coastal Water Temperature Guide*. National Oceanic and Atmospheric Administration. Web.
3. Namias, Jerome. "Atlantic Ocean - Hydrology." Encyclopedia Britannica Online. *Encyclopedia Britannica*. Web.

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